Update on Bi2212 Multiscale modeling

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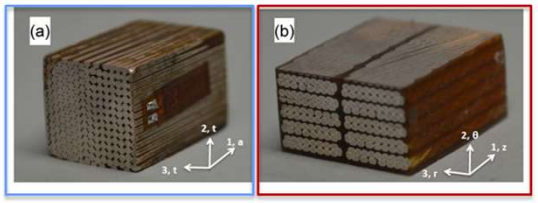
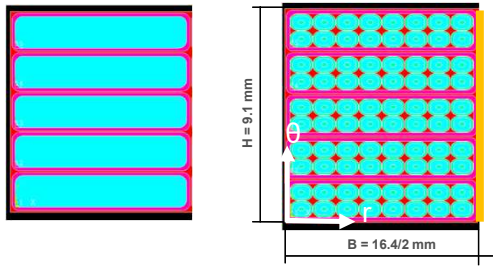
08/27/2024

Bi-2212 10-stack Analysis



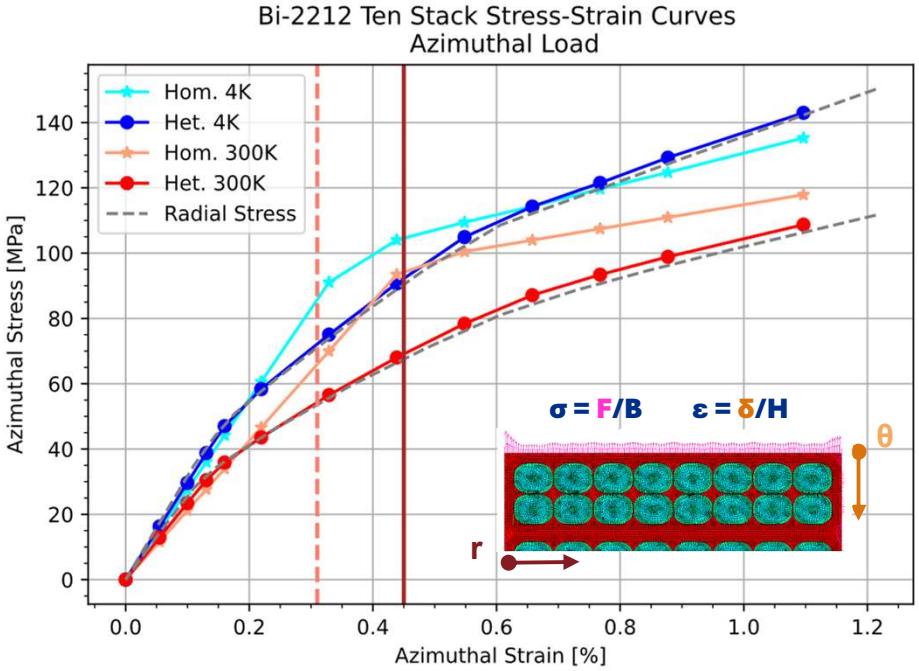
Strand composite sample

Rutherford cable composite sample



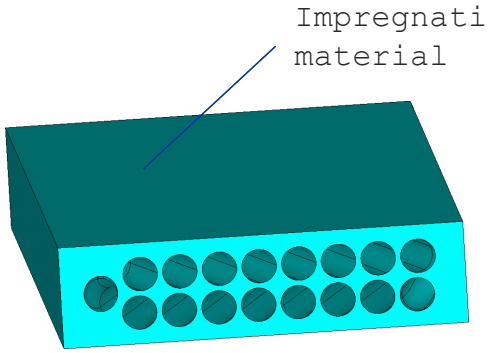
2D models implemented:
- homogeneous orthotropic
- heterogeneous composite with isotropic materials

Thermal-Mechanical Properties of Epoxy-Impregnated Bi-2212/Ag Composite Pei Li, Yang Wang, Arno Godeke, Liyang Ye, Gene Flanagan, and Tengming Shen, *Member, IEEE*



- The stress/strain curve of the **hom**. and **het**. models are plotted at **room** and **cold** temperature, **radial** and **azimuthal** directions.
- To investigate the axial behavior, 3D model might be necessary.
- The Bi-2212 **strain % limit of 0.32%** can be reached with irreversible current degradation. From the plot, after that strain %, the hom. model **stiffness is higher** than the het. model. That value of strain can be easily reached in Bi-2212 strands in hybrid dipoles.

APDL 3D Ten Stack Module – Bi-2212 Rutherford Cable Sample



3 Inputs

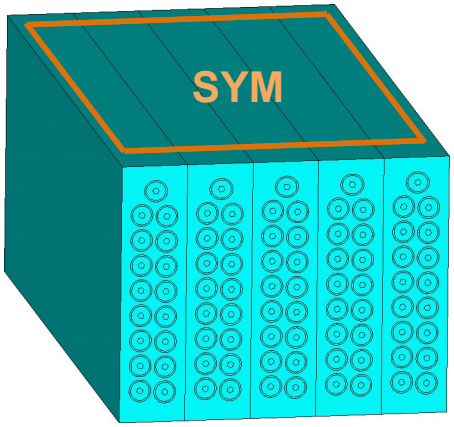
$$n = 17$$

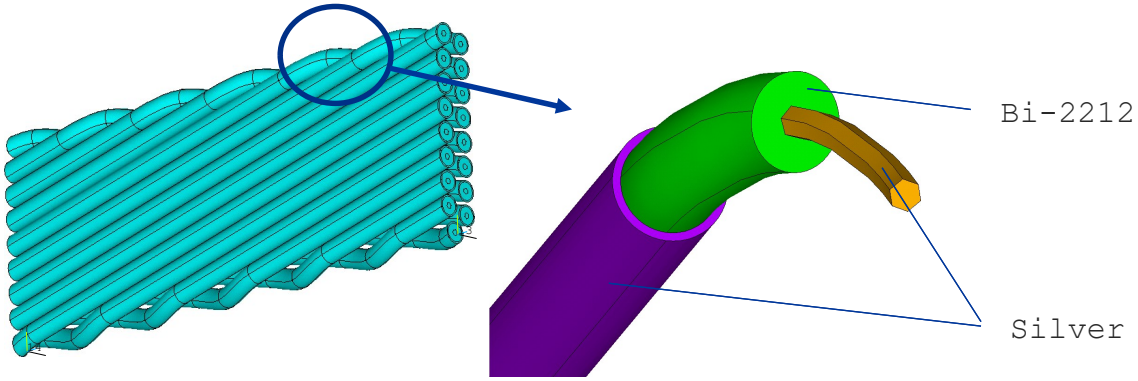
$$d = 0.8\text{mm}$$

$$L = n \cdot p = \frac{n \cdot d}{\sin(\phi)} = 58 \text{ mm}$$

$$\phi = \arcsin \frac{n \cdot d}{L} \approx 13.56 \text{ deg}$$

$$p = \frac{d}{\sin(\phi)} \approx 3.41 \text{ mm}$$



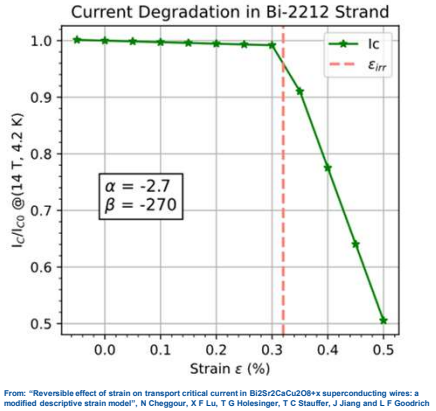


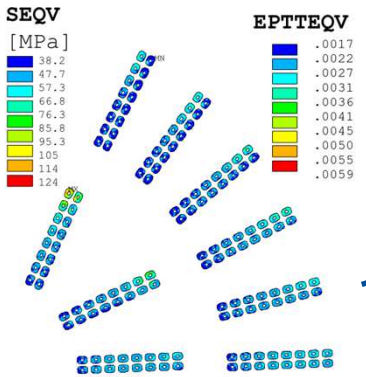
Simulation steps done:
- Geometry
- Components definition and material allocation
- Mesh

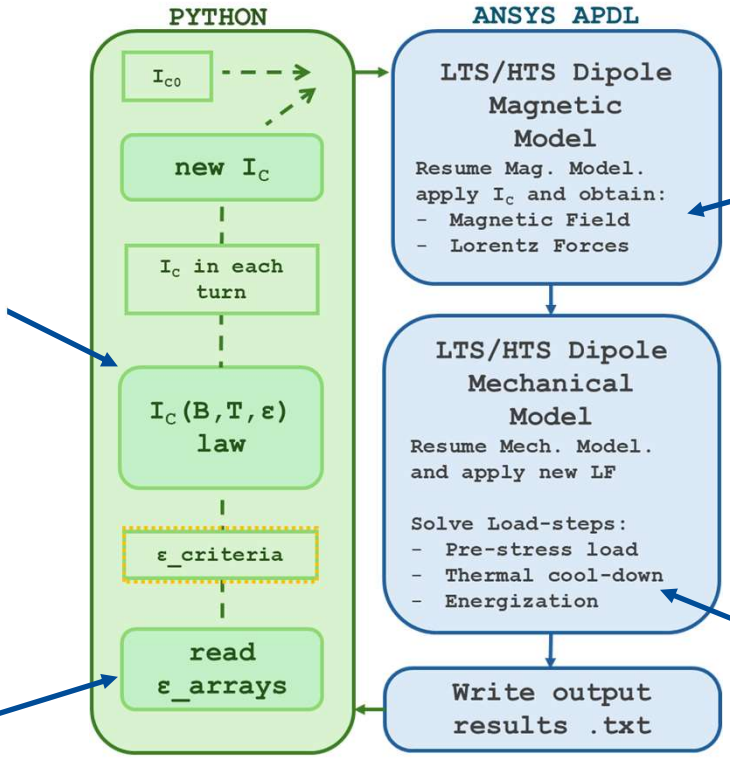
Remaining steps:
- Contacts definition
- Periodic Constraints / BC / Loads

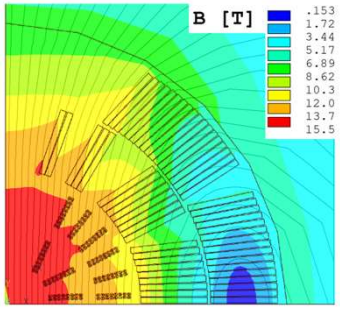
Fermilab

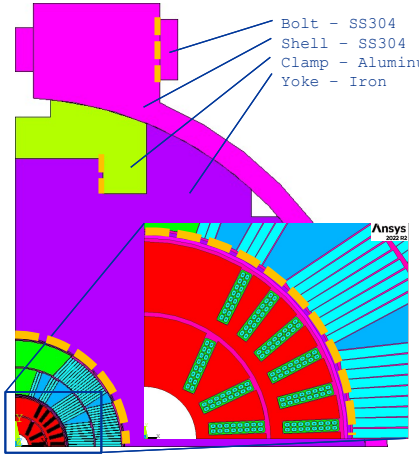
LTS/HTS Hybrid Dipole Analysis with Current Degradation (1/2)



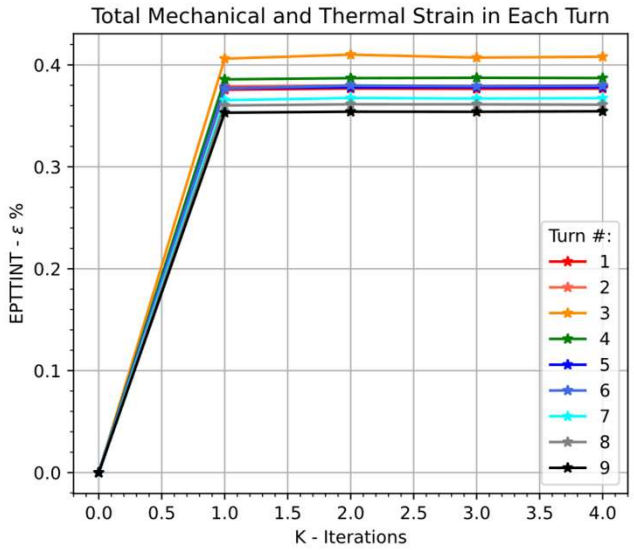


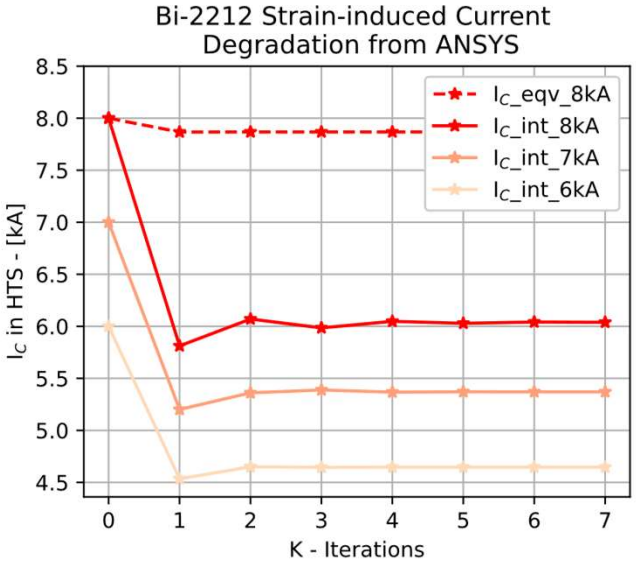






LTS/HTS Hybrid Dipole Analysis with Current Degradation (2/2)





Considering the most conservative ε criteria, the average current degradation is around 23.6 % (24.5 % at 8 kA and a 22.6 % of I_C reduction at 6 kA). The next steps are:

- compare the homogeneous model results within the same analysis
- consider transverse pressure as law for current degradation (the law need to be calibrated depending on Rutherford cable behavior)

Analysis Conclusion and Needs

- Heterogeneous Rutherford cable model allowed to apply current degradation at strand level, obtaining detailed stress/strain state from mag-mech analysis.
- Connection with .py code allowed to investigate results after the first iteration (at higher I_{C0} current converge slower).
- $I_c(B, T, \varepsilon)$ was used, future steps could be including or replacing ε with σ in the degradation law.

- Obtain up-to-date Bi-2212 Rutherford cable material properties could improve analysis quality.
- Need for experimental tests on dipoles. Easier, re-adapt the analysis simulating tested magnet configurations to validate the model.